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Analysis of IEC 61727 Photovoltaic (PV) systems Characteristics of the utility interface

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Abstract

This paper describes IEC 61727 standard of Photovoltaic (PV) systems -Characteristics of the utility interface. IEC 61727 standard tests include utility compatibility and personnel safety and equipment protection of PV inverter performance functions. Especially utility compatibility part includes test items of 1) voltage, current and frequency, 2) normal voltage operating range, 3) flicker, 4) DC injection, 5) normal frequency operating range, 6) harmonics and 7) waveform distortion, 8) power factor of PV inverter. Also personnel safety and equipment protection part includes test items 1)loss of utility voltage, 2)over/under voltage and frequency, 3)Islanding protection, 4)response to utility recovery, 5)earthing, 6)short circuit protection, 7)Isolation and switching of PV inverter. In this paper, each item of IEC 61727 standard test is studied and analyzed and finally full tested by PV inverter performance function.

Keywords: *IEC 61727 standard, Photovoltaic (PV) systems, utility interface, PV inverter performance functions*

1. Introduction

The increase in the size and the uptake of PV systems is leading to significant increase in the penetration of PV into local electricity grids. The increased penetration of PV is impacting on grid operation and in particular the voltage within the local grid can be significantly influenced by the various PV systems.

The current global situation of environmental pollution, climate change and energy demand urgently requires dramatic political, economic and technical decisions - in order to avoid a potential collapse of environmental and social systems. Around the world, electricity remains the vital component of national and international development.

The implementation of renewable energy resources can provide solutions to these challenges by stimulating the early implementation of economically viable sustainable energy technologies.

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stimulating the early implementation of economically viable sustainable energy technologies.

Therefore this paper describes IEC 61727 standard of Photovoltaic (PV) systems -Characteristics of the utility interface. IEC 61727 standard tests utility compatibility and personnel safety and equipment protection of PV inverter performance functions. Especially utility compatibility part includes test items of 1) voltage, current and frequency, 2) normal voltage operating range, 3) flicker, 4) DC injection, 5) normal frequency operating range, 6) harmonics and 7) waveform distortion, 8) power factor of PV inverter.
Also personnel safety and equipment protection part includes test items 1)loss of utility voltage, 2)over/under voltage and frequency, 3)Islanding protection, 4)response to utility recovery, 5)earthing, 6)short circuit protection, 7)Isolation and switching of PV inverter.

In this paper each test item of IEC 61727 standard is studied and analyzed and finally full tested by PV inverter performance function.

2. Analysis of IEC 61727

To test and analyze each test item of IEC 61727, we full tested with PV inverter of performance function. Tested PV inverter of specifications is as it follows;

The full tests of PV inverter will be conducted in the laboratory at KTL according to IEC 61727. At the KTL PV laboratory, we use the DC and AC power simulator to test PV inverter performance based IEC 61727 standard.

Table 1. PV Inverter Specifications

Type	-
Max. Input Voltage	500 Vdc
MPPT Voltage range	100 Vdc ~ 500 Vdc
Rated Power AC	3.1 kW
Rated Output Frequency	60 Hz
Rated Output Voltage	220 Vac
Rated Output Current	14.1 A

3. Test Results

3.1 Utility compatibility

1) Voltage, current and frequency

The PV system AC voltage, current and frequency shall be compatible with the utility system.

Utility	380/220Vac 60Hz	Result	remark
Voltage	220	P	-
Current	14.1	P	-
Frequency	60	P	-

2) Normal voltage operating range **Result : P**

Because utility-interconnected PV systems do not normally regulate voltage, they inject current into the utility. Therefore, the voltage operating range for PV inverters is selected as a protection function that responds to abnormal utility conditions, not as a voltage regulation function.

3) Flicker

The operation of the PV system should not cause voltage flicker in excess of limits stated in the relevant sections of IEC 61000-3-3 for systems less than 16 A or IEC 61000-3-5 for systems with current of 16 A and above.

4) DC injection

The PV system shall not inject DC current greater than 1 % of the rated inverter output current, into the utility AC interface under any operating condition.

Rated inverter output current (A)	Output DC current (A)	Result (P/F)	remark
14.1	1.07	F	-

5) Normal frequency operating range **Result: P**

The PV system shall operate in synchronism with the utility system, and within the frequency trip limits defined in IEC 61727.

6) Harmonics and waveform distortion

Total harmonic current distortion	Less than 5%	result	2.78%
Odd harmonics		Even harmonics	
3rd through 9th	Less than 4,0 %	2rd through 8th	Less than 1,0 %
11th through 15th	Less than 2,0 %	10th through 32nd	Less than 0,5 %
17th through 21st	Less than 1,5 %	-	-
23rd through 33rd	Less than 0,6 %	-	-

No.	A	Hdf %	No.	A	Hdf %
1	13.620	99.77	2	0.168	1.23
3	0.148	1.09	4	0.029	0.21
5	0.030	0.22	6	0.025	0.18
7	0.036	0.26	8	0.030	0.22
9	0.030	0.22	10	0.027	0.19
11	0.043	0.32	12	0.025	0.18
13	0.033	0.24	24	0.027	0.20
15	0.030	0.22	16	0.028	0.20
17	0.035	0.26	18	0.031	0.22
19	0.030	0.22	20	0.028	0.20
21	0.030	0.22	22	0.028	0.20
23	0.030	0.22	24	0.033	0.24
25	0.033	0.24	26	0.022	0.16
27	0.026	0.19	28	0.030	0.22
29	0.037	0.27	30	0.032	0.23
31	0.029	0.21	32	0.030	0.22
33	0.034	0.25			

7) Power factor

The PV system shall have a lagging power factor greater than 0,9 when the output is greater than 50 % of the rated inverter output power.

Output power (W)	Power factor	Result (P/F)	remark
Rated output power	0.99	P	-

3.2 Personnel safety and equipment protection

1) Loss of utility voltage **Result: P**

To prevent islanding, a utility connected PV system shall cease to energize the utility system from a de-energized distribution line irrespective of connected loads or other generators within specified time limits.

2) Over/under voltage and frequency

clause	Trip level (at point of utility connection)	Maximum trip time [sec]	Result [sec]	remark
5.2.1 Over/under voltage	V < 0,5 ×V nominal	0,1	0.01	-
	50 % ≤ V < 85 %	2,0	0.01	-
	85 % ≤ V ≤ 110 %	Continuous operation	-	-
	110 % < V < 135 %	2,0	0.47	-
	135 % ≤ V	0,05	0.05	-
5.2.2 Over/under frequency	Hz ≤ 59Hz	0,2	0.15	-
	61Hz ≤ Hz	0,2	0.11	-

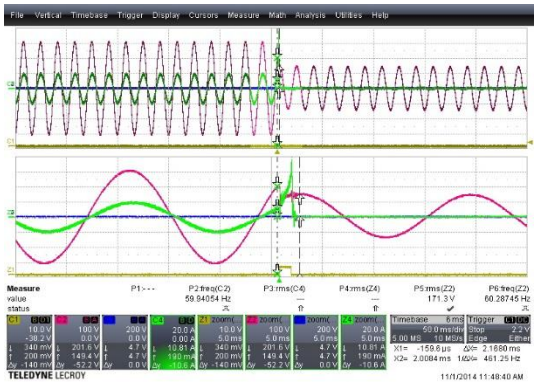

Figure 1. V < 0,5×V nominal

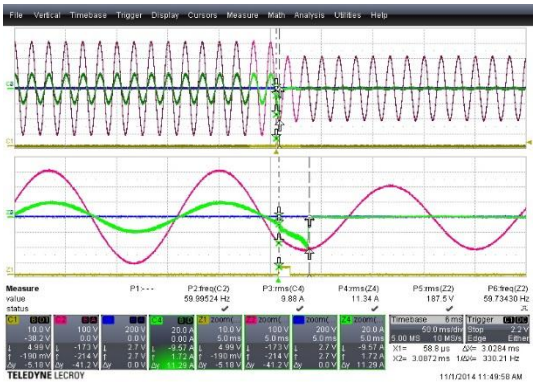

Figure 2. 50 % ≤ V < 85 %

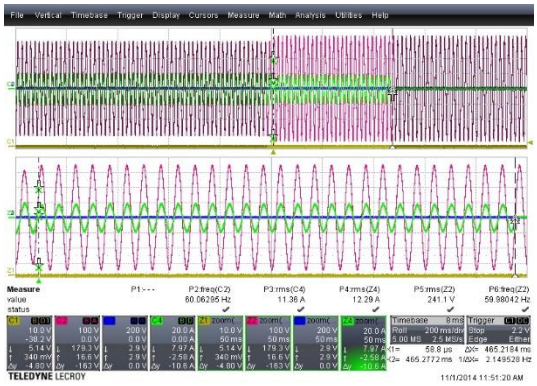

Figure 3. 110 % < V < 135 %

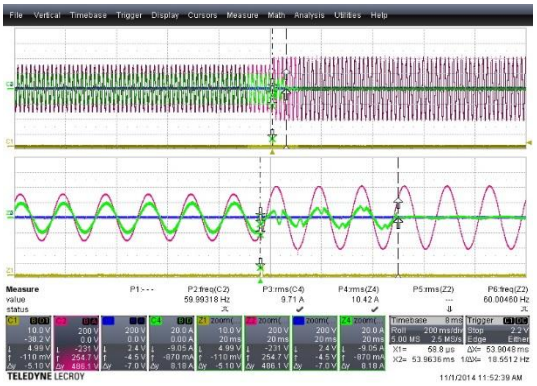

Figure 4. 135 % ≤ V

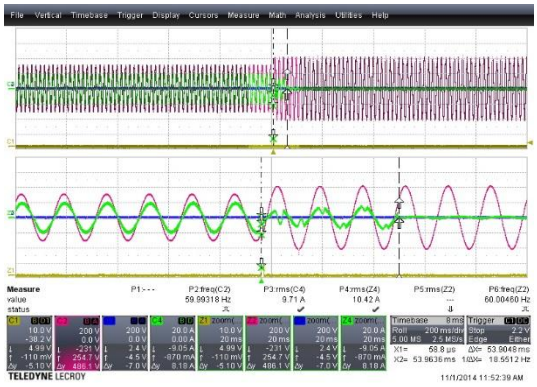

Figure 5. Hz ≤ 59Hz

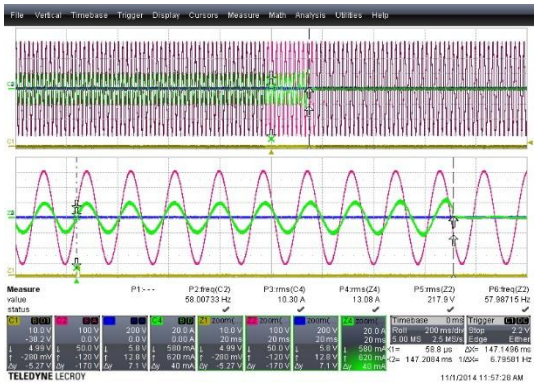

Figure 6. 61Hz ≤ Hz

Fig.1~Fig.4 are test result of over and under voltage test and trip level(at point of utility connection) is same as table description. Also Fig. 5 and Fig. 6 are test result of over and under frequency test in accordance with description in table.

3) Islanding protection **Result: P**

The PV system must cease to energize the utility line within 2 s of loss of utility.

4) Response to utility recovery

Following an out-of-range utility condition that has caused the photovoltaic system to cease energizing, the photovoltaic system shall not energize the utility line for 20 s to 5 min after the utility service voltage and frequency have recovered to within the specified ranges.

No.	Reconnection time	Result (P/F)	remark
1	301[sec]	P	-

5) Earthing **Result: P**

The utility interface equipment shall be earthed / grounded in accordance with IEC 60364-7-712.

6) Short circuit protection **Result: P**

The photovoltaic system shall have short-circuit protection in accordance with IEC 60364-7-712.

Therefore test result of short circuit protection shows the Fig. 7

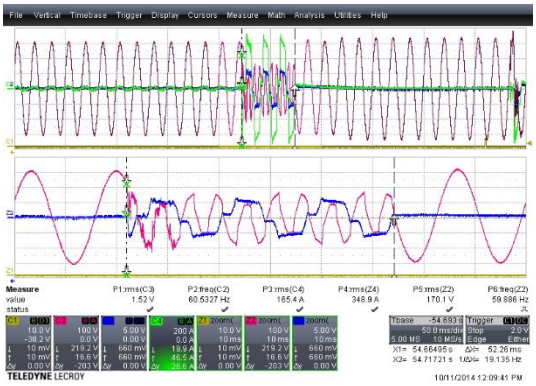

Figure 7. Short circuit protection

4. Conclusions

In this paper, based IEC 61727 standard, we conducted fully PV inverter to verify performance and certification each test item. Also now we studied and analyzed IEC 61727 standard of each test method and procedure. Finally our KTL PV laboratory is official test institution of IEC 61727 and issues the test report of PV inverter.

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